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THE RUST OF COWPEAS

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WITH PLATE I

In a previous paper[2] the writer, together with S. A. Wingard, briefly discussed a rust of the cowpea (*Vigna sinensis* (L.) Endl.) which was found to be distinct in pathogenicity from the bean rust (*Uromyces appendiculatus* (Pers.) Fries to which it has commonly been assigned. Additional study of the cowpea rust has shown that it is distinct in morphology from the bean rust, as well as in pathogenicity, and it is presented herein as a clearly defined species.

MORPHOLOGY

The most distinctive feature is found in the location of the urediniospore germ-pores; a character of marked taxonomic value which has been used extensively by Arthur and other workers in his laboratory.[3] The urediniospores of *U. appendiculatus*, according to Arthur's description in the North American Flora, show 2, rarely 3, equatorial pores. My study of the species on kidney bean confirms this as to location of pores. They are invariably in the equatorial zone and are always 2 in number (Fig. 1, B; Pl. I, fig. 2). I have seen no spores, however, in which 3 pores could be clearly distinguished. The urediniospores of the cowpea rust also show 2 pores but their position is distinctly superequatorial (Fig. 1, A; Pl. I, fig. 1). They are more distinct than are those of bean rust and are often seen in the untreated spore; they are clearly visible after treatment with lactic acid. The pores of bean rust are not easily seen except after treatment and then, as a rule, only when the spore is

[1] Paper 60 from the Department of Plant Pathology, Virginia Agricultural Experiment Station.

[2] Fromme, F. D., and S. A. Wingard. Varietal susceptibility of beans to rust. Jour. Agr. Res. **21**: 385–404. 1921.

[3] Arthur, J. C., and F. D. Fromme. Taxonomic value of pore characters in the grass and sedge rusts. Mycologia **7**: 28–33. 1915.

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in such a position that the pores appear in the side walls. This difference in visibility is probably due to the darker wall of the spore from cowpea. A slight distinction is also seen in the surface markings of the spores; the echinulations are closer and less prominent in the cowpea rust than in the bean rust. The uredinia on the cowpea are darker in color and larger, as a rule, than those on bean (Pl. I, fig. 3).

The teliospores are very similar (Fig. 1, A and B), but those from cowpea usually show a slightly thinner side wall and less apical thickening; they are also of the lepto or non-resting type, a point that will be discussed later, while the teliospores of bean rust apparently require a considerable after-ripening period before they are capable of germination.

The aeciospores of the two rusts are indistinguishable (Fig. 1, A and B) but the arrangement of the aecial groups is distinctive. Fisher[1] describes the aecia of *U. appendiculatus* as often in "kreuz formige" groups and this is true of the aecia on Phaseolus seen by the writer. The groups suggest crosses (Pl. I, fig. 4) or rosettes (Pl. I, fig. 5) according to the number of aecia. The aecial groups are small, the average number of aecia to the group being 7 and the range from 4 to 12. This grouping has not been seen in the cowpea rust. The aecia here are in the usual annulate group on slightly raised areas (Pl. I, fig. 6). The groups are considerably larger than are those on bean and they average about 50 aecia to the group.

The presence of superequatorial pores in the rust of Vigna has been noted by Arthur,[2] but at that time he apparently considered this a varietal distinction rather than a specific one. In a discussion of material on *Vigna repens* and *V. vexillata* from Porto Rico he writes:

> While the pores in the urediniospores of this species are usually two or three, and equatorial, they are sometimes four in number and sometimes are distinctly superequatorial. The Stevens' collections from Porto Rico show only uredinia, and the spores are 2-pored. On Phaseolus the pores are mostly equatorial, but on Vigna they are markedly superequatorial.

He makes a similar comment in a later paper[3] as follows:

> The collection on *Vigna vexillata*, made by Mr. Johnston, shows urediniospores with two or three pores, varying from equatorial to markedly superequatorial, a condition also noted in the Porto Rican rusts on this host genus. The species is autoecious, but

[1] Uredineen der Schweiz, p. 19.

[2] Arthur, J. C. Uredinales of Porto Rico. Mycologia **7**: 185. 1916.

[3] Arthur, J. C. Uredinales of Cuba. Memoirs Torrey Bot. Club **17**: 129. 1918.

the pycnia and aecia have not been reported from the tropics, and even telia are somewhat rare. The rust is cosmopolitan on Dolichos, Phaseolus, Strophostyles, Vigna, and probably other genera.

SYNONYMY OF COWPEA RUST

The foregoing treatment of the cowpea rust is that commonly followed; it is referred to *U. appendiculatus* in all taxonomic treatments of this species seen by the writer and commonly passes under this name in current literature. There are, however, eleven rust species which have been described on species of Vigna. Four of these are species of Aecidium, two species of Uredo, and five species of Uromyces. They are listed in the following:

Aecidium vignae Cooke, on *Vigna marginata*, Natal, South Africa, Grev. **8**: 71. 1879; *A. nigro-cinctum* Pat. & Har., on *Vigna sp.*, French Indo-China, Bull. Myc. Fr. **22**: 116. 1906; *A. caulicola* P. Henn., on *Vigna sp.*, Dembo, central Africa, An. Mus. Congo **2**: 95. 1907; *A. decipiens* Syd., Monog. Ured. **4**: 223. 1923.

Uredo purpurascens P. Henn., on *Vigna sp.*, central Africa, An. Mus. Congo **2**: 93. 1907; *U. vignae* Bres., on *V. lutea*, St. Thomas, West Indies, Rev. Myc. **13**: 66, for 1891.

Uromyces vignae Barcl., on *Vigna vexillata*, Simla, India, Jour. Asiat. Soc. Bengal **60**: 211. 1891; *U. pazschkeanus* P. Henn., on *Vigna sp.*, Abyssinia, Bull. Herb. Boiss. **1**: 107. 1893; *U. vignicola* P. Henn., on *Vigna sp.*, Africa, Eng. Bot. Jahrbr. **38**: 103. 1905; *U. punctiformis* Syd., on *V. strobilophora*, Mexico, Ured. 1513, 1901; *U. vignae luteolae* P. Henn., on *V. luteola*, Africa, An. Mus. Congo **2**: 95. 1907.

Only two of these species, *U. vignae* Barcl., and *U. vignae luteolae* P. Henn., can be assigned with any degree of certainty to the rust of cowpea under discussion. Although the writer has seen no material of Barclay's species there can be little question as to its identity. The type collection was made near Simla, India, on *Vigna vexillata* (L.) A. Rich.,[1] a cosmopolitan species which is represented in the Arthur herbarium[2] by three rust collections, two from Cuba and one from Porto Rico. These have been examined and found identical with the rust of *V. sinensis*. Barclay describes the urediniospores of *U. vignae* as:

[1] It is to be noted that Barclay cites the host as *V. vexillata* Benth. but Richard's name antedates this. The two refer to the same species.

[2] The writer is indebted to Dr. J. C. Arthur and to Purdue University for the loan of herbarium material, and also to Dr. Arthur for critical reading of this manuscript.

Brownish red, oval to round, thin walled, very spiny and with a few immature teleutospores among them. They measured when fresh and just wetted 26–29 × 19–18 μ. The teleutospores are deep brown, oval, very deciduous, with a portion of colourless stalk adherent, with a pale-brown, shallow mammila, and a smooth surface. The fresh spores just wetted measured 35–27 × 22–20 μ. The portion of adherent stalk measured up to 40 μ in length.

The close similarity of these measurements with those of the species under discussion leaves little doubt as to their identity. It seems probable also that *U. vignae luteolae* is identical with this species as it is listed by Sydow as synonymous with *U. appendiculatus* to which he also assigns the rust of *V. sinensis*.

None of the species of Aecidium described from Vigna can be placed with any certainty and probably none of them relates to the rust in question. *Aecidium caulicola* has small aeciospores, 10–15 μ according to Hennings, and *A. vignae* has aecia in large groups on strongly hypertrophied areas of the leaf blade and petiole.

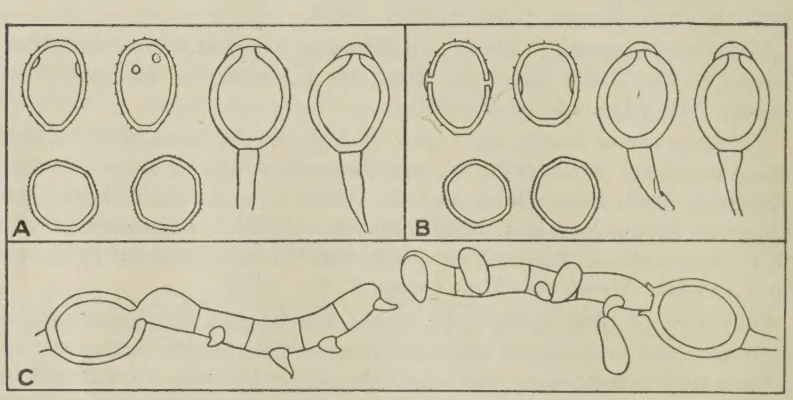


FIG. 1. A. Aeciospores, urediniospores and teliospores of *Uromyces vignae* from *V. sinensis*. The urediniospores show 2 superequatorial pores. B. Aeciospores, urediniospores and teliospores of *U. appendiculatus* from *Phaseolus vulgaris*. The urediniospores show 2 equatorial pores. C. Germinating teliospores of *U. vignae*.

Uredo vignae has been transferred by Arthur (Bull. Torrey Club **44**: 509. 1917) to Phakopsora, a genus in which the uredinia are bordered by a delicate cellular peridium, and *U. purpurascens* has small urediniospores.

The urediniospores of *Uromyces punctiformis* are thin walled with 2 inconspicuous, approximately equatorial pores, and are readily distinguished from those of *U. vignae*. The telia of this species are minute and the teliospores are punctate and have long pedicels. Arthur has placed it under *U. appendiculatus* (N. Am. Flora 7^3: 257. 1912) but it appears to the writer to be a valid species. It is known only by the type collection. *U. vignicola* although described as a rust is said to be a Synchytrium. The status of *U. pazschkeanus* is in doubt. According to Sydow the teliospores are distinguishable by thick pedicels which swell in water. No urediniospores are described. A specimen which comes from the region of the type, collected by G. Schweinfurth on *Vigna sp.*, Eritrea, Akrur, February 14, 1894, and labeled *U. pazschkeanus*, shows urediniospores 20–22 × 23–27 μ, with 2 superequatorial pores, and is identical with *U. vignae* in other respects. The specimen may be incorrectly named, however, and it seems best to leave the assignment of this species open for the present.

A critical examination of material previously listed under *U. appendiculatus* shows the following to be additional hosts for *U. vignae:—Dolichos lablab*, *Phaseolus truxillensis*, *Vigna repens* and *V. sesquipedalis*. A point of unusual interest is found in the occurrence of both species on *Dolichos lablab*. *U. vignae* occurs on two collections of this host from Cuba, as cited later under hosts, and on one from India, while a collection from Jamaica, lower slopes of Mt. Moses, April 14, 1903, L. M. Underwood, and one from Krakau, Bot. Garden, August, 1891, M. Raciborski, both bear rusts readily identified as *U. appendiculatus*. All material seen on the other hosts of *U. vignae* as listed is referable to this species. The occurrence of *U. vignae* on *Phaseolus truxillensis* is somewhat surprising in view of the fact that no other species of Phaseolus, so far as is known, bears this rust. *Dolichos melanophthalmus* DC. which is found to bear *U. vignae* is said by Piper[1] to be a cultivated, blackeyed cowpea of the Mediterranean region synonymous with *V. sinensis*.

The following hosts appear to be correctly placed under *U. appendiculatus: Phaseolus adenanthus* G. Meyer, *P. anisotrichus* Schl., *P. atropurpureus* Moc. & Sesse, *P. coccineus* Jacq., *P. disophyllus* Benth., *P. lunatus* L., *P. obvallatus* Schlecht., *P. polystachyus* (L.) B. S. P., *P. retusus* Benth., *P. vulgaris* L. The status of the rust on *P. lathyroides* L., *P. sinuatus* Nutt., *Strophostyles helvola* (L.) Britton, *S. pauciflora* (Benth.) S. Wats., and *S. umbellata* (Muhl.) Britton is not so clear.

[1] Piper, C. V. Agricultural varieties of cowpea. U. S. Dept. Agric., Bur. Pl. Ind. Bull. 229. 1912.

These have all been referred to *U. appendiculatus* but all show pores slightly above the equator, somewhat intermediate in position between the equatorial pores of this species and the distinctly superequatorial pores of *U. vignae*. They cannot be placed properly with the latter species and they are atypical for *U. appendiculatus*. It is possible that a third species is involved. I have attempted to culture the Strophostyles rust on both beans and cowpeas without success but the circumstances attending the attempts do not warrant a statement that the rust will not pass to either under optimum conditions. Arthur[1] has shown that the Strophostyles rust is autoecious and that it has teliospores of the resting type by producing aecia in the spring with overwintered teliospores.

It seems desirable to supply a more detailed description of the rust of Vigna than that given by Barclay. The pycnia and aecia have not been described and the uredinia and telia have features of taxonomic value not included in Barclay's description. The species is also transferred to the genus Nigredo according to Arthur's treatment of the rusts.

Nigredo vignae (Barcl.) comb. nov.

Uromyces vignae Barcl. Jour. Asiat. Soc. Bengal **60**: 211. 1891.
Uromyces vignae luteolae P. Henn. An. Mus. Congo **2**: 95. 1907.

0. Pycnia epiphyllous, in small circular groups, honey-yellow, becoming brownish, globose or broadly so, 100–125 μ in diameter; ostiolar filaments short.

I. Aecia chiefly hypophyllous and petiolicolous, in circular groups, 2–4 mm. across, often with annular arrangement, low-cupulate, small, 0.2–0.3 mm. in diameter; peridium whitish, rather evanescent, margin spreading, irregularly lacerate; peridial cells rhomboidal or oblong, slightly imbricated, 16–20 × 20–25 μ, the outer wall 3–5 μ transversely striate, smooth, the inner wall 2–3 μ, verrucose; aeciospores ellipsoid or oblong ellipsoid, 16–20 × 20–26 μ; wall colorless, 1–1.5 μ, minutely and closely verrucose.

II. Uredinia amphigenous and petiolicolous, scattered, roundish, rather large, about 1 mm. or less in diameter, soon naked, chestnut-brown, ruptured epidermis evident; urediniospores ellipsoid or ovate-ellipsoid, 18–22 × 24–30 μ; wall cinnamon-brown, moderately thin, 1.5–2 μ, finely and closely echinulate, the pores 2, readily distinguished, markedly superequatorial.

[1] Arthur, J. C. Cultures of Uredineae in 1903. Jour. Myc. **10**: 14. 1904.

III. Telia amphigenous and petiolicolous, roundish, about 0.5 mm. in diameter, early naked, blackish-brown, somewhat pulverulent, ruptured epidermis evident; teliospores broadly ellipsoid, 20–25 × 27–35 μ, rounded or obtuse above, usually rounded below; wall dark chestnut-brown, smooth, moderately thick, 2–2.5 μ, apex 4–6 μ including the hyaline, hemispherical umbo; pedicel hyaline, fragile, rarely equalling the spore length; germinating at maturity.

The collections listed below have been examined by the writer.

On *Dolichos lablab* L., Santiago de las Vegas, Cuba, November 3, 1917, J. R. Johnston; Regla, Prov. Havana, Cuba, April 8, 1903, J. A. Shafer (from phanerogamic specimen); Kanaighat, India, May 24, 1905, E. J. Butler (Sydow Ured. 2101).

On *Phaseolus truxillensis* H.B.K., San Jose, Costa Rica, January 10, 1916, Holway, 397.

On *Vigna repens* (L.) Kuntze, Miami, Florida, March 25, 1903, Holway; Punta Rassa, Lee County, Florida, February 26, 1916, P. C. Standley, 12670; Arecibo, Porto Rico, May 21, 1913, F. L. Stevens, 1760; Mayaguez, Porto Rico, March 3, 1916, Whetzel & Olive, 201; Bahia Honda, Pinar del Rio, Cuba, December 14, 1910, Percy Wilson (from phanerogamic specimen).

On *Vigna sesquipedalis* (L.) W. F. Wight, Honomo, Hawaii, May 1920, L. O. Kunkel.

On *Vigna sinensis* (L.) Endl., Alhambra, California, Fall, 1919, D. C. Milbrath; Ames, Iowa, Fall, 1901, Estella Rhinehart; Lafayette, Indiana, October 17, 1902, J. C. Arthur (N. Am. Ured. 381); Lafayette, Indiana, October 26, 1903, J. C. Arthur; Suling, Texas, August 26, 1909, Heald & Wolf, 2260; Leesville, Texas, August 1, 1902, C. L. Shear; Brownsville, Texas, May 10, 1912, W. P. Carr; Manchester, Missouri, September 26, 1906, H. Von Schrenk; Columbia, Missouri, September 23, 1906, B. M. Duggar; Grady, Alabama, July, 1923, S. A. Wingard; Pensacola, Florida, July 26, 1909, G. W. Carver (N. Am. Ured. 86); Bell, Maryland, August 2, 1921, J. T. Rogers; Arlington Farm, Virginia, September 16, 1907, G. Graham; Blacksburg, Virginia, August 7, 1922, S. A. Wingard; Oahu Sugar Company, Oahu, Hawaii, July 23, 1919, Lyon; Nujingyan, Burma, January 24, 1908, E. J. Butler (Sydow Ured. 2451); Parma, Italy, July, 1874, Passerini (Thüm. Myc. Univ. 40).

On *Vigna vexillata* (L.) A. Rich., Toa, Baracoa, Cuba, April 17, 1916, J. R. Johnston, 586; Campo Florido, Prov. Havana, Cuba, July 18, 1912, Bro. Leon (from phanerogamic specimen); Mayaguez, Porto Rico, June 14, 1913, F. L. Stevens, 2216.

On *Vigna sp.*, Eritrea, Akrur, February 14, 1894, G. Schweinfurth.

The locality of the type collection is near Simla (on Tara Devi), India, on *Vigna vexillata* (L.) A. Rich. (*V. vexillata* Benth).

GEOGRAPHIC DISTRIBUTION

A survey of recent literature gives a number of additional localities and adds materially to the distribution of the rust of cowpea as shown by the herbarium material examined. The rust is, of course, cited as *U. appendiculatus*. An examination of specimens would be necessary before these citations could be placed without question under *U. vignae* but there seems little doubt that the following are referable to this species.

On *Vigna luteola*, Columbia, Central Andes, Mem. Soc. Neuchat. **5**: 462. 1914; Argentine, Hedwigia **35**: 223. 1898.

On *Vigna sesquipedalis*, Philippine Islands, Leaf. Phil. Bot. **6**: 2076. 1914.

On *Vigna sinensis*, Japan, An. Myc. **20**: 82. 1922; Philippine Islands, Phytopathology **9**: 139. 1919; Ceylon, Yearbook Ceylon Soc. Agr. **1919–1920**: 117. 1919; Cuba, Informe Estac. Exp. Agron. Cuba **1918–1919, 1919–1920**: 723–763. 1921; China, An. Phytopath. Soc. Japan **1**: 66. 1921; Russia, Bur. Myc. & Phytopath. Petrograd **1**: 23–41. 1915; India, An. Myc. **10**: 256. 1912.

Apparently the rust of Vigna is cosmopolitan and occurs practically coextensively with the distribution of its hosts in southern Europe, Asia, Japan, the Philippines, the Hawaiian Islands, Africa, South America, Central America, the West Indies, and the United States especially in the southern part. It is recorded from the states of Maryland, Virginia, Alabama, Florida, Indiana, Iowa, Missouri, Texas, and California.

INFECTION STUDIES

The rust material used in the infection studies has been obtained from several sources. The first material came from D. C. Milbrath and was collected at Alhambra, California, in the fall of 1919. It consisted of fresh leaves of Blackeye cowpea bearing viable urediniospores of *U. vignae*. The rust was established in the greenhouse on Blackeye plants and was carried over winter with occasional transfers.

A sowing of 18 varieties of cowpea and 19 varieties of kidney bean was made in the field at Blacksburg, Virginia, in the spring of 1920 and after

suitable growth these were inoculated with urediniospores taken from Blackeye plants in the greenhouse. The inoculation was made on July 10 and uredinia were first noted on the plants of Blackeye on July 22. The infection had developed vigorously on this variety by July 29 and on this date a careful inspection of the other varieties of cowpeas and beans was made. No infection was found on any of the beans and infection of the cowpeas was restricted to four varieties of the Blackeye type recorded as follows:

Vigorous infection: Blackeye.

Slight infection: Large Blackeye, Extra Early Blackeye, Ramshorn Blackeye.

Flecks only: Black, Brabham, Clay, Cream Crowder, Gallavant, Groit, Iron, New Era, Red Ripper, Taylor, Two-Crop Clay.

No flecks nor sori: Crowder, Rice or Cream Pea, Whippoorwill.

The infection at this time consisted of uredinia and telia, the latter occurring especially on the older leaves. It continued to develop vigorously on the Blackeye plants which suffered severe defoliation in consequence. In late August, much to our surprise, an abundant development of aecia was noted on the plants of this variety. Uredinia and telia were found in considerable numbers on Extra Early and Ramshorn Blackeye at this time but there were no aecia and none also on Large Blackeye which showed only slight infection. There were no sporulating sori on any of the other varieties.

An attempt to carry the rust over winter in the greenhouse was a failure owing to the low temperatures maintained which were unsuited to the growth of cowpeas. During the spring of 1921 Blackeye cowpeas with other varieties were sown in the same location in the field as in 1920 in the hopes that infection might result from over-wintered material, but no infection occurred throughout the season. A culture of the rust from Blackeye was again obtained, however, on August 28, 1921, from the farm of the County Experiment Station at Chatham, Virginia. The rusted Blackeye plants were in a variety test which also included the varieties Black, Brabham, Clay, Groit, Iron, Taylor, New Era and Whippoorwill, none of which showed infection. Although the rust was in the telial stage only an attempt to establish a culture was made on Blackeye plants in the greenhouse on September 10. Pycnia followed by aecia appeared on the inoculated plants on September 19. A second sowing of the material from Chatham was made on other Blackeye plants on September 19 and pycnia were obtained on September 28.

Aeciospores from the culture of September 19 were used as inoculum

in the greenhouse on October 18 on plants of Blackeye and Black cowpea, on adsuki bean (*Phaseolus angularis* (Willd.) W. F. Wight), asparagus bean (*Vigna sesquipedalis*), hyacinth bean (*Dolichos lablab*), mung bean (*P. aureus* Roxb.), bubb catjang (*V. catjang* (Burm.) Walp.), rice bean (*P. calcaratus* Roxb.), sword bean (*Canavalia gladiata*), scarlet runner (*P. multiflorus* Willd.), and urd bean (*P. mungo* L.). Infection (uredinia) was obtained only on Blackeye. A repetition of the foregoing test was made November 1, using urediniospores from Blackeye on the same series of plants. Vigorous infection was obtained on Blackeye and none resulted on any of the other plants. A third attempt made on the same series of plants growing in a garden at Blacksburg in the summer of 1922 gave the same results. No plants except those of Blackeye showed infection. Several additional attempts were made to secure infection with the cowpea rust on a number of varieties of kidney bean and lima bean, but all were without success.

From the foregoing it is apparent that the rust of cowpea is closely limited in its host range. Of the varieties of cultivated cowpeas tested it has infected only Blackeye and closely related strains and has produced no infection on the kidney, lima or other types of bean included in the tests.

Piper's observations (l. c.) on the development of rust in cowpeas under comparative tests at Arlington, Virginia, furnish additional data as to varietal susceptibility. He writes:

> Rust is a disease to which most standard American varieties of cowpeas are immune. Many recently imported varieties, especially from China and India, are, however, very susceptible to this disease and suffer severe injury from it. That other varieties are completely immune to rust would appear from the fact that they are never affected even when growing contiguous to a rusted variety on the same ground for several years in succession, which has been the experience at Arlington Farm. This disease was very much in evidence at Arlington in 1908 and 1909, but was entirely absent in 1910.

Piper's tests included a large number of named varieties and in addition a number of importations from foreign countries many of which are listed by number only. Notes as to behavior with respect to rust infection are included in the descriptions and discussions of the varieties and introductions. The named varieties of cowpea on which the presence of rust is recorded are: Browneye, Chinese Black, Chinese Red and Chinese Whippoorwill. It also occurred on a number of the unnamed introductions of cowpea, catjang and asparagus bean. The following varieties of cowpea are recorded as free from rust: Ayrshire, Black, Black

Crowder, Blackeyed Lady, Brabham, Brown Coffee, Brown Crowder, Browneye Crowder, Cotton Patch, Cream, Delaware Red, Early Black or Congo, Early Blackeye, Early Red, Grayeye, Groit, Guernsey, Holstein, Iron, Lady, Louisiana Wild, Michigan Favorite, New Era, Old Man, Panmure Early Wonder, Peerless, Powell Early Prolific, Purple-Podded Clay, Ramshorn Blackeye, Red Crowder, Red Ripper, Red Whippoorwill, Red Yellowhull, Self-Seeding Clay, Sixty-Day, Small Black Crowder, Smallpox, Southdown, Speckled Crowder, Taylor, Unknown, Unknown Blackeye, Warren New Hybrid, Watson, Whippoorwill, Whippoorwill Crowder, White Giant, Wight Black Crowder.

It is to be noted that none of the varieties recorded as susceptible to rust by Piper were included in our tests and that the observations with respect to those varieties which were included in both tests are in agreement except that the writer obtained moderate infection on Early Blackeye and Ramshorn Blackeye while Piper records these varieties as free from rust. Certain introductions of asparagus bean were found to be susceptible by Piper while others were rust free. My attempts to infect asparagus bean were made with a single variety, Yard Long, and it seems probable that successful infection might have been obtained if more varieties or strains had been available. It is possible, of course, that there are two or more biologic strains of the cowpea rust. According to L. O. Kunkel the rust of asparagus beans is common in the Hawaiian Islands. In a latter dated March 14, 1920, he writes:

> I have not found rust on beans out here (Honolulu) and there is no record of its occurrence here at the station. However, what is supposed to be the same thing is common enough on the Yard Long bean, *Vigna sp.* I have collected rust on this host on this island and also on the island of Hawaii. Phaseolus plants are always free from rust.

Although I have made no extended test of teliospore germination with either the cowpea or bean rust it is evident from their behavior in culture that *U. vignae* has teliospores of the non-resting type, while those of *U. appendiculatus* require a considerable period of after-ripening prior to germination. Aecia of *U. vignae* have been produced in the field in August from teliospores produced during the same season, and also in the greenhouse on several occasions during fall, winter and spring from teliospore inoculation. This occurred in two separate trials in September, 1921, with teliospores taken from the field and again in November, 1922. Teliospores taken from the field November 24, 1922, showed germination on this date but none were viable in later tests. A culture carried through the winter of 1919 in the greenhouse produced aecia in the spring from teliospore inoculation. The rust had gone through

several uredinial generations in the greenhouse and the teliospores used as inoculum had been produced but a short time previously.

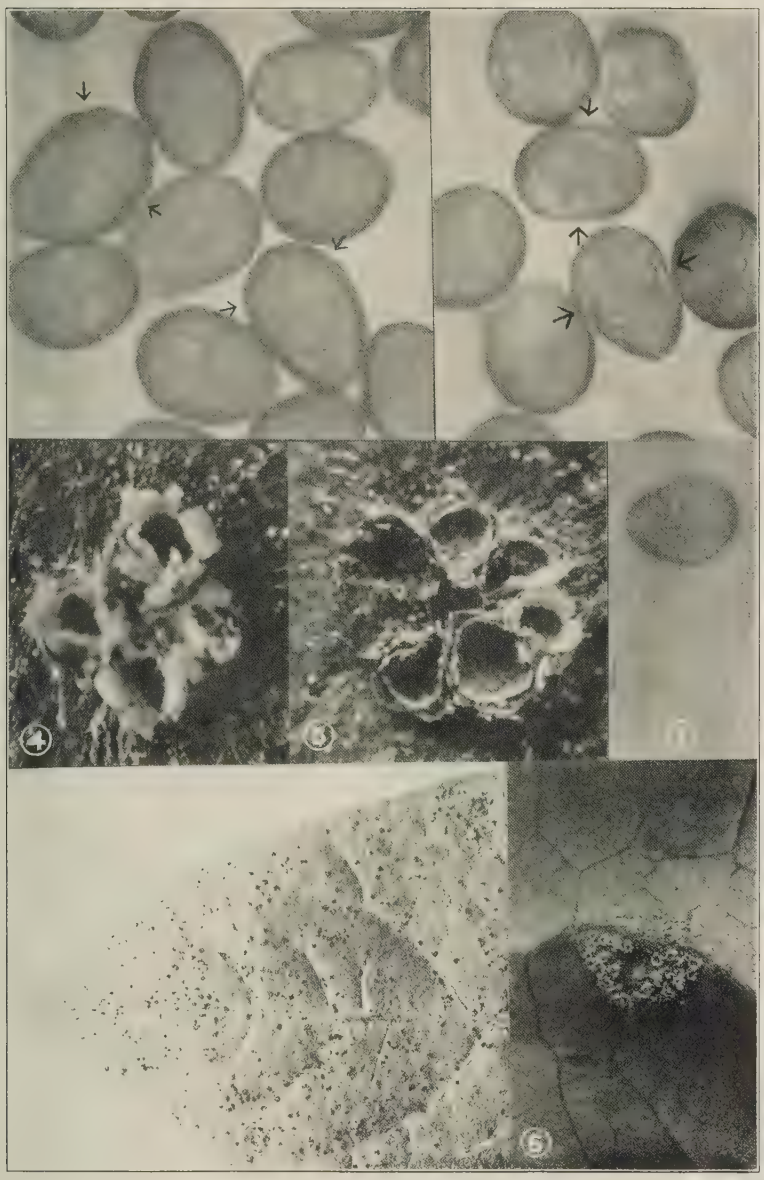
In contrast with this behavior of the cowpea rust the bean rust during seven years of experimental study in both greenhouse and field has never produced aecia. The writer has watched for the initial appearance of bean rust in gardens in spring and early summer and invariably uredinia only have been observed, followed later in the season by telia. Teliospores at the time of maturity have been used as inoculum without results. No systematic attempt at the overwintering of teliospores has been made and evidence in regard to their germination is lacking. Such evidence as may be gained from a study of herbarium material indicates that aecia of bean rust are rare in the United States and it seems probable that the teliospores do not function as a rule in the overwintering of the fungus. Specimens of bean rust in the Arthur herbarium and in that of the U. S. Department of Agriculture have been examined, and although a great many collections from North America are present only one shows aecia; this is on *P. vulgaris* from LaCrosse, Wisconsin, July 25, 1908. A collection by Underwood on *Phaseolus sp.* from Jamaica, September 2–10, 1906, also shows aecia but the identity of the host is somewhat doubtful. Several European collections which show aecia have been seen by the writer but they are said by Fisher (l. c.) to occur but rarely in Europe. I know of but one additional collection from North America on Phaseolus which shows aecia. This material which is of a pole bean (*P. vulgaris*) was sent me from a garden at Blacksburg, Virginia, on July 8, 1916. I did not know at the time that aecial production in the bean rust was unusual and did not visit the garden to study the case.

So far as I am aware no one has carried the bean rust through its complete cycle or developed aecia from teliospore infection except possibly deBary[1] who, however, gives no details of his work with this species. He states that he obtained the same results with the rust of beans as with *Uromyces fabae* for which he describes cultures establishing the relation between the three spore forms. There seems no question as to the autoecism of the bean rust but the fact has not been established on as definite a basis as is desirable.

SUMMARY

The rust of cowpeas which has commonly been considered identical with the rust of beans, *Uromyces appendiculatus*, is presented as a clearly

[1] deBary, A. Recherches sur le development de quelques champignons parasites. An. Sci. Nat. Bót. IV. **20**. 1863.



RUST OF COWPEA

defined species and is assigned to *Uromyces vignae* as described by Barclay from *Vigna vexillata*. A new description of the species is given. Marked distinguishing features between the two species are found in the grouping of the aecia, the location of urediniospore germpores, and in the germination of the teliospores. The teliospore of *U. vignae* is of the non-resting type while that of *U. appendiculatus* is of the resting type.

Occurrence of *U. vignae*, from a study of herbarium material, is recorded on four species of Vigna, one of Dolichos and one of Phaseolus.

Infection studies with a strain of the rust obtained from the Blackeye variety of cowpea show it to be closely restricted in its host range. It has infected only a few varieties or strains of the Blackeye type. The great majority of cowpea varieties grown in the United States are immune or highly resistant. No infection has been obtained on hyacinth bean or asparagus bean which are hosts according to the taxonomic treatment. This failure may be due to lack of the proper variety or strain of these hosts for testing or it may be that there is more than one biologic strain of the rust.

Uromyces vignae has produced aecia under field conditions in August and during fall, winter and spring in the greenhouse from newly matured teliospores. It is the only full-cycled, autoecious rust known to the writer which completes its full cycle under greenhouse conditions.

EXPLANATION OF PLATE I

FIG. 1. Urediniospores of *Uromyces vignae* from Blackeye cowpea. The pores are designated by arrows and are superequatorial. Approximately 900 ×.

FIG. 2. Urediniospores of *U. appendiculatus* from Tenenssee Green Pod bean. The pores, designated by arrows, are equatorial. Approximately 900 ×.

FIG. 3. Uredinia of *U. vignae* on a leaf of Blackeye cowpea. About 1½ ×.

FIG. 4. Aecia of *U. appendiculatus* from *Phaseolus vulgaris* showing "kreuz formige" grouping. The group contains 4 aecia. About 30 ×.

FIG. 5. Aecia of *U. appendiculatus* from *P. vulgaris* showing rosette grouping. The group contains 7 aecia. About 30 ×.

FIG. 6. Aecia of *U. vignae* on a leaf of Blackeye cowpea showing annulate grouping. About 5 ×.

FIG. 7. Urediniospore of *U. appendiculatus* showing the germ-tube issuing from an equatorial pore. Approximately 600 ×.